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Breeding Ecology of the Ferruginous Hawk in Northern Utah and Southern Idaho

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BREEDING ECOLOGY OF THE FERRUGINOUS HAWK IN NORTHERN UTAH AND SOUTHERN IDAHO

by

Richard P. Howard

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of

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"The work of gathering detailed information about all raptors nesting over a large area is an exhausting task. It is, paradoxically, also most exciting--a pleasure that stimulates at the time and lingers long in memory."

John and Frank Craighead (1956)

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Richard Phillip Howard

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ABSTRACT

Breeding Ecology of the Ferruginous Hawk in

Northern Utah and Southern Idaho

by

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Utah State University, 1975

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Forty-three and 54 ferruginous hawk (Buteo regalis) pairs were found occupying territories in northern Utah and southeastern Idaho during 1972 and 1973, respectively. Of these 38 and 27 nesting pairs laid eggs. Nesting success was 77.1 percent in 1972 and 74.6 percent in 1973. For successful nests, an average of 2.9 and 2.6 young hatched and 2.7 and 2.3 young fledged during the respective years. This population is reproductively comparable to others in Utah and Colorado. Analysis of prey items collected from the nests indicated that black-tailed jackrabbits (Lepus californicus) constitute 86 percent of the biomass (by weight) of three major prey species consumed by ferruginous hawks in this area. Jackrabbit density may be a major determinant of the number of young produced in a given year. Weight gained by the nestlings showed a marked sexual dimorphism. Female fledglings weighed up to 1.43 times as much as males. Criteria were developed for sexing ferruginous hawks by measuring the diameter of the hallux. Mortality of 17 birds from the study area was recorded, of which 47 percent were immature birds. A total of 108 fledglings were banded and marked with color-coded patagial

wing markers. Band reports of five (10 percent) of these birds were received. Utah Juniper (Juniperus osteosperma) provided nest sites for 96.0 percent of the nests while three percent were built on the ground. Plant community types were determined at 63 nesting sites from aerial photographs. Dominant vegetation around nest sites were desert shrub types and crested wheatgrass (Agropyron cristatum) seedings. The possible impact of land management practices on ferruginous hawks is discussed.

(70 pages)

INTRODUCTION

The ferruginous hawk (Buteo regalis), largest of the Buteos in North America, can be observed soaring overhead or perching on fence posts in western deserts and mid-western grasslands. It breeds from Alberta, Canada to Arizona, and from Washington to North Dakota. Major prey species include prairie-dogs (Cynomys sp.) (Bent 1937) in its eastern range and lagomorphs in the west (Smith and Murphy 1973).

Much of the former habitat of this species has been altered by farming and settlement. New hazards of attrition such as land conversion, strip mining and geothermal exploitation threaten the habitat which this species requires. The National Audubon Society has placed the ferruginous hawk on the Blue List. The Blue List is defined as those species or subspecies that "are suffering population declines or range diminution in all or parts of their range, but are not now of sufficient rarity to be considered endangered (American Birds 1972). The U. S. Department of the Interior lists the ferruginous hawk as status "undetermined" (U. S. D. I. 1968). A recent report from Oregon State University (1969) classifies ferruginous hawks in that state as endangered.

Historically, Bendire (1892), Cameron (1914) and Bowles (1931) described its natural history. Salt (1939) mapped migration routes of 22 hawks banded in Alberta, Canada. Recent studies have provided some information on its status and ecology (Weston 1969; Olendorff 1972). Angell (1969) investigated adult and brood behavior at one nest in Washington.

Many areas in the intermontane deserts of the west support local populations of ferruginous hawks. Based on brief surveys made by Porter (1951) in Raft River Valley, Idaho and Platt (1971) in Curlew Valley, Utah, I concluded that intensive surveys of these valleys were justified. A substantial number of breeding pairs were found in both areas. In a cooperative effort with Leon Powers of Idaho State University, I designed a two-year study of this species. My objectives were: (1) to determine nesting density and reproductive success; (2) to document food habits; (3) to determine weight gained by nestlings; (4) to identify mortality factors; and (5) to analyze vegetation around nest sites.

STUDY AREA

The 2797 km^2 study area (Figure 1) consists of parts of two intermontane basins, Curlew Valley and Raft River Valley, and is bisected by the Black Pine Mountains. Curlew Valley (1212 km^2) is located in the southwestern portion of Oneida County, Idaho and extends southwest into Box Elder County, Utah. The southern end of the Raft River Valley (1585 km^2) is located in Box Elder County, Utah and extends north into Cassia County, Idaho. The study area is bordered by the North Promontory and the Raft River Ranges. These mountains vary in altitude from 2148 to 3045 meters. This area lies within the northern or "cold desert" region of the United States (Odum 1959). Cold desert topography is typical below 1700 m. Above this elevation the area becomes mountainous.

Annual precipitation in the study area varies from 25-30 cm at the southern part to 36-41 cm at the northern, much of it occurring as snow in winter. Annual temperatures range from -32° C in January to 38°C in July. Mean monthly temperatures range from -6°C in January to 21°C in July (Mitchell 1965).

Vegetation in Curlew and Raft River valleys lies within the northern desert shrub biome and comprises three altitudinal delineations (Cronquist et al. 1972). The "Shadscale" (Atriplex confertifolia) zone occurs in saline valley soils at altitudes below 1373 meters. In association with shadscale, greasewood (Sarcobatus vermiculatus) is found around recently flooded mud flats and in dry streambeds. At somewhat higher elevations, usually above 1525 meters, big sagebrush (Artemisia tridentata), which occurs in the second major zone ("Sage Zone"), is often found as a

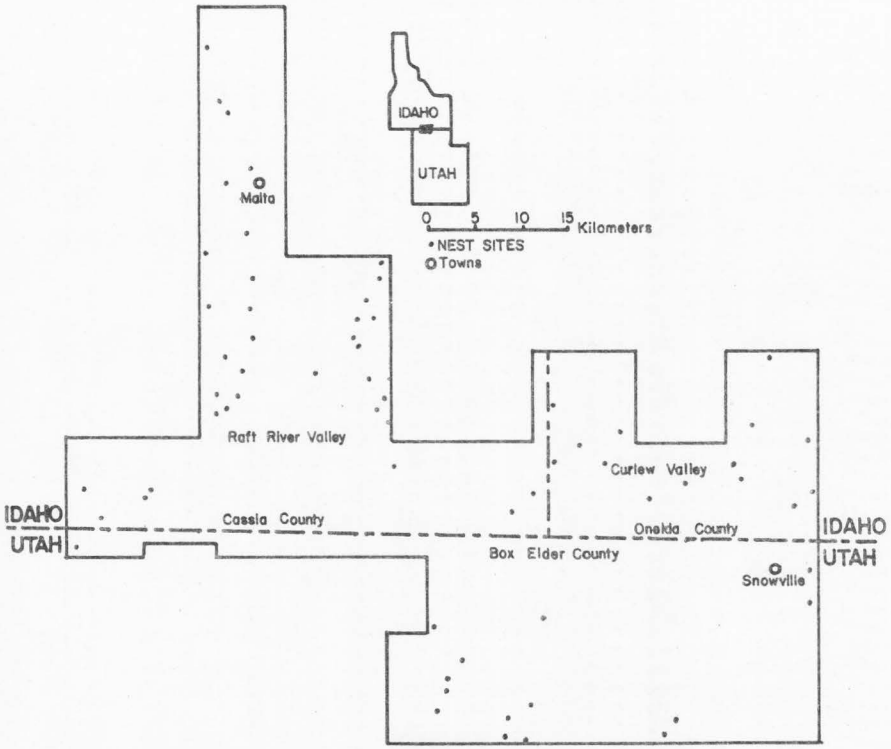

Figure 1. Location of study area and nest sites.

monotypic stand. Other shrub dominants in this zone may include black sage (Artemisia nova) and rubber rabbitbrush (Chrysothamus nauseous). Utah juniper (Juniperus osteosperma) and at higher elevations pinyon pine (Pinus edulis) occur in the third major zone ("Pinyon-Juniper Zone"). The elevational range of the zone varies but below 1525 meters is determined by lack of moisture.

Extensive crested wheatgrass (Agropyron cristatum) seedings for livestock are found in both valleys. Agricultural crops include alfalfa (Medicago sativa) and cereal grains. Most of the farms are located in the Sage Zone.

The native fauna includes 26 species of rodents and lagomorphs. There are 12 species of reptiles represented and 34 species of passerine birds. Raptors are represented by two species of eagles, eight species of hawks, and six species of owls. The observed status of birds of prey in the study area is listed in Appendix A.

METHODS

During 1972 and 1973, field work was initiated in March and continued through July. Using available roads, a systematic search was conducted for ferruginous hawks attending nests. A two-meter aluminum ladder facilitated climbing to those nests found in trees. In 1972, several nests with eggs in the early stages of incubation were abandoned after climbing to them. Consequently, no nests were visited until late May in 1973. Nests were checked at a distance for activity. Nest locations were marked on a topographic map (scale 1:250,000) and assigned a number. A log was kept of each visit made to a nest. In 1972, 152 visits were made to 43 nests and 119 visits were made to 54 nests in 1973.

A portable blind was used at several nests. Distance from the blind to the nests varied between 45 and 140 meters. Observations of nesting activity were made from the blind with a 25-power scope.

Since Curlew and Raft River valleys comprise discrete geographical units, mean distances between nests were computed for each valley. Nesting densities were computed both on the basis of total number of occupied territories and successful nests. Occupied territories were those areas where at least one bird was observed tending a nest(s) or two birds were seen in the nest vicinity. The presence of one or more eggs in a nest was defined as a nesting attempt. A successful nest was one from which one or more fledged young were produced. Densities were determined by dividing the number of townships in which pairs were found by the total number of occupied territories and successful nests.

In 1972, three consecutive vists were made to each successful nest to obtain information on egg production, number of young hatched and number of birds fledged. In 1972, clutch size was observed directly. Later nest visits were made in 1973 and the number of young and unhatched eggs counted to reconstruct clutch size. Productivity was calculated on the basis of young fledged per potential adult pair, nesting attempts and successful nests. When nestling were approximately 35-40 days old, patagial wing markers, color-coded according to individual, nest and nesting area were attached. During this marking process, the young were also banded with U. S. Fish and Wildlife Service bands.

In 1972, no regular nest visits were made but prey item and pellet samples were collected from 19 randomly selected nests. In 1973, seven nests with a total of 18 young were selected for regular collection of food habit data. Four were located in crested wheatgrass seedings and three were in desert shrub. These nests were visited every four days. Collections made between 0830 and 1030 hours produced the largest number of prey items. Identifiable remains were left in the nest if only partially consumed but prey specimens were collected for later analysis where identification of the remains was uncertain. Regurgitated pellets were collected and analyzed for identifiable prey. Only skulls and teeth found in pellets were counted. Contents of pellets and nonpellet items were identified at the same nest (Craighead and Craighead 1956). Food habit data were classified according to date, location, species and body part.

Percent frequency of occurrence for all prey items and biomass for the three major prey species was calculated for each year. Biomass was determined using the following mean weights: black-tailed jackrabbit

(Lepus californicus), 2100 grams, (Stoddart, 1972a); Townsend ground squirrel (Spermophilus townsendi), 248 grams, (Scheffer 1941); northern pocket gopher (Thomomys talpoides), 100 grams, (Turner et al. 1973).

In 1972 and 1973, hallux size and body weights were recorded for 49 birds whose hatching dates were known within one day. Birds were marked with dye and weighed from one to six times during the period prior to fledging. A Hanson postal scale, with a capacity of 2268 gr. and accuracy to 14 gr. was employed for weighing the birds. While 37 birds were weighed in 1972 during nest visits to monitor development, 12 birds were arbitrarily selected from four nests in 1973 to be weighed every four days. After the 49 young attained an age of 30 days or more, the flexed hallux was measured with a Fowler caliper; accuracy was to 0.1 mm.

Young birds were banded in the nest with Fish and Wildlife bands. Observations of mortality were begun in the fall of 1971 during a preliminary survey of the study area. Gross necropsies of dead birds found in 1972 and 1973 were conducted in the field. Hallux measurements and body weights were not recorded because of the dehydrated condition of dead birds.

The central portions of 15 nests were collected and examined by an entomologist (Whitworth, 1973) as a possible source of myiasis. No attempts were made to culture bacteria or identify helminths.

A total of 97 structures used for nest sites were identified. Vegetational analysis was made of habitat surrounding 63 ferruginous hawk nests. Composition of plant types was determined from aerial photographs taken between 1966 and 1971. Photographs were not available for the entire study area. Nest sites were located on 24.1 x 24.1 cm

photos of the study area (scale 2.54 cm = 438 meters). Location of nest sites and vegetative features on the photos were validated in the field. A scaled circle (3.85 km^2) was drawn on tracing paper overlay using the nest site on the photo as the center. Of nine hunting forays by paired adults, eight were observed within 0.8 km of their respective nests. One foray was observed to occur 1.9 km from the nest. The mean distance was used as a basis for arbitrarily defining a hunting territory. An obvious problem is that territories are seldom, if ever, circular; however, lacking range data for all nesting pairs each year, a standard circle with 3.4 cm radius was employed. Luttich et al. (1970) used a similar method to classify vegetation surrounding red-tailed hawk (Buteo jamaicensis) nests. They based the nesting season range of red-tailed hawks on data collected by Craighead and Craighead (1956).

Plant types were identified and mapped within the circle. General plant types included five categories: (1) desert shrub comprising the "shadscale" and "sage" zones; (2) crested wheatgrass in various stages of reversion to sagebrush; (3) juniper forest; (4) alfalfa fields; and (5) cereal crops. The circle was then cut into specific plant types and each segment weighed on a Mettler B-5 electronic balance. Percent composition of each vegetation type was calculated from the weights. To test for variability in weights of circles, ten samples were weighed independently. The mean was 306.4 (s.e. $\pm$ .058) mg.

RESULTS AND DISCUSSION

Breeding Biology

Breeding population

Forty-three and 54 ferruginous hawk pairs were found occupying territories in 1972 and 1973. Some error may have occured because it took three days to survey the study area. During this time, previously counted pairs may have established different nest sites, thus being counted again. This source of error is probably minimal since only two pairs were observed attending alternate nests on the study area. In these situations, the paced distance between alternate nests was no more than 150 meters. Weston (1968) found breeding pairs attending up to five nests, but no two nests were more than 0.16 kilometers apart.

Within the study area, 30 (70 percent) nests were reoccupied in 1973. Five of the remaining 13 nests were destroyed by wind in the winter of 1972. Old nests were found within 0.16 to 0.96 kilometers from 14 nests occupied in 1972. Six of these old nests were occupied in 1973. Only two new nests were known to have been constructed in 1973.

Distribution and density

Distances between 43 occupied territories ranged from 0.8 to 14.0 km and averaged 3.6 km in 1972. In 1973 distances ranged from 0.8 to 16.0 km and averaged 3.7 km for 54 nests (Table 1). Weston reported a smaller range of values (0.6-3.7 km) in Cedar Valley, Utah. Since all occupied nests in my study area were not located, due to limited access, the resultant estimates shown are conservative. They are, however,

comparable for the two years of the study because the techniques and relative effort employed in the location of nests were the same in 1972 and 1973.

Areal densities for occupied territories and successful nests in Curlew and Raft River valleys are shown in Table 1. Student's T-test (T=4.19, P=.05, df=7) revealed a significant difference between average area in 1972 and 1973 for occupied territories and successful nests. The increase in area per successful nest observed from 1972 to 1973 may reflect changes in the territorial limits of breeding pairs dependent upon prey abundance. The observed densities are lower than those reported by Smith and Murphy (1973) for ferruginous hawks in Cedar Valley, Utah. During a four-year study, they reported densities ranging from 15.5 km^2 to 25.9 km^2 per pair.

Breeding chronology and dynamics

Based on an incubation period of 35 days (Olendorff 1973), the calculated median date of egglaying was 14 April and 17 April in 1972 and 1973 respectively. Hatching dates ranged from 29 April through 1 June in 1972 and 8 May through 5 June in 1972 (Table 2). Smith and Murphy (1973) observed hatching dates ranging from 5 May through 26 May in 1969 and 22 April through 5 May in 1970. Olendorff (1973) reported hatching dates ranging from 21 May through 11 June in Colorado. The number of eggs per clutch ranged from one to five in 1972 and one to four in 1973 (Table 3). Mean clutch size per nesting attempt was 2.78 and 2.77 respectively. Platt (1973) found average clutch size for 11 pairs was 3.54 in Curlew Valley during 1969. Smith and Murphy (1973) reported an average clutch size of 3.22 eggs per nest during the period

Table 1. Linear distance and areal density of occupied territories and successful nests for Curlew and Raft River valleys, 1972 and 1973.

Location	Year	No. of nests	km^2	Linear distance			Areal density	
				Range	$\bar{X}$ distance	S.D.	km^2/ occupied territory	km^2/ successful nest
Curlew	1972	24	1129	0.8-14.0	3.6	2.6	46.6	
Curlew	1972	18	1129					62.1
Curlew	1973	25	1212	0.8-16.0	4.6	3.3	48.4	
Curlew	1973	13	1212					57.4
Raft River	1972	19	839	0.8- 9.7	2.9	2.6	44.3	
Raft River	1972	13	839					64.7
Raft River	1973	29	612	0.8- 4.6	1.7	1.5	54.6	
Raft River	1973	13	932					71.7
						$\bar{x}$	48.4	64.0

Table 2. Breeding chronology of ferruginous hawks in northern Utah and southern Idaho observed during 1972 and 1973.

	1972	1973
First observation of adults in the study area	4 March	8 March
Earliest laying date	26 March	3 April
Median laying date	14 April	17 April
Latest laying date	26 April	2 May
Earliest hatching date	29 April	8 May
Median hatching date	18 May	21 May
Latest hatching date	1 June	5 June
Earliest brood departure date	14 June	20 June
Latest brood departure date	14 July	18 July
Average number of days young were in the nest	45	43
Breeding season (days)	104	105

Table 3. Frequency distribution of clutch size and average clutch size in ferruginous hawk nests, 1972 and 1973.

	Clutch size						
	1	2	3	4	5		
Year	Percent	Percent	Percent	Percent	Percent	Mean	S.D.
1972	15.8	18.4	39.5	23.6	2.6	2.78	1.1
1973	7.4	18.5	63.0	11.1		2.77	1.1

of 1967-1970 in west-central Utah. In the Pawnee National Grasslands clutch size averaged 3.14 eggs per nesting attempt from 1970 to 1972 (Olendorff 1972).

Seven nest failures in 1972 and four in 1973 occurred during incubation. Successful and unsuccessful nests were inspected for egg

losses (Table 4). In 1972, three pairs abandoned when their nests were visited during the early stages of incubation. Olendorff (1973) and Powers et al. (in press) caution researchers about visiting ferruginous hawks during incubation. Overheating and dehydration of the eggs may occur rapidly when the incubating adult leaves the nest. Late evening nest visits may not allow the adult time to return before dark, thus causing the eggs to cool overnight.

Table 4. Egg mortality in successful and unsuccessful nests.

	No. of eggs	Successful nests			Unsuccessful nests		
		Fertile	Infertile	Other	Infertile	Human Caused	Other
1972							
Curlew	61	48	1	1	4	7	-
Raft River	48	41	1	-	-	3	3
Total No.	109	89	2	1	4	10	3
Percent		82	2	trace	3	9	3
1973							
Curlew	36	26	1	3	2	-	4
Raft River	39	32	2	-	-	-	5
Total No.	75	58	3	3	2	-	9
Percent		77	4	4	3	-	12

Although the normal incubation period is 35 days (Olendorff 1973), one pair of birds in Curlew Valley incubated eggs for 51 days. I estimated that the eggs addled 20 to 25 days after being laid. Another pair in Curlew Valley abandoned after 809 hectares in the nest vicinity were

plowed and planted with crested wheatgrass. The edge of the treated area came to within three meters of the nest.

Four nests containing eggs were blown over by the wind in 1973. During late May, when incubation was well advanced, two situations were observed where nests containing eggs were not being attended by either adult. In one instance, both adults were seen returning to the nest, but nest defense behavior was not observed. These were aberrant behavior patterns, as one bird is usually found on the eggs during incubation and both adults defend the nest (Angell 1969). The absence of both adults at a nest site suggests that the prey base in these areas was low enough that both of the adults were forced to hunt simultaneously.

In no case was a renesting attempt or second clutch of eggs found. In 1972, a nest containing one egg was blown over. Apparently this was an incomplete clutch, because the female attending that site laid the remaining clutch in a nearby alternate nest.

During 1972 and 1973, 54 of 65 total nesting attempts (82 percent) were successful. Nesting success was 77.1 and 74.5 percent in 1972 and 1973 respectively (Table 5). During a two-year study in Cedar Valley, Utah, Weston (1968) reported 67 and 85 percent nesting success for 27 occupied nests. In two areas in northeastern Colorado, one inclusive of the other, Olendorff (1972) reported nesting success of 40 and 73 percent. On a continuous block of shortgrass prairie within the above study area, nesting success was 50 and 70 percent for six and ten pairs, respectively (Olendorff 1973).

Of young hatched in 1972, 84 (94.3 percent) fledged from the nest while 56 (96.5 percent) fledged in 1973. Reduction in the actual number of young fledged for 1973 may be related to a major decline in jackrabbits

Table 5. Breeding dynamics of ferruginous hawks in the study area.

Year	No. pairs	Nesting attempts	Successful nests	No. young	No. fledged	Nesting success (%)
1972	43	38	31	89	84	77.1
1973	54	27	23	58	56	74.5
Totals	97	65	54	147	140	

and is discussed below. For occupied territories an average of 1.89 and 1.03 young fledged in 1972 and 1973 respectively (Table 6). Platt (1971) recorded 3.41 young fledged per nest in Curlew Valley in 1969. Comparison of production in other areas revealed considerable variation. Smith and Murphy (1973) reported 2.66 and 1.42 young fledging per nest in 1969 and 1970 in west central Utah. Olendorff (1973) tallied an average of 1.83, 2.45 and 2.90 birds fledged per successful nest from 1970 to 1972 in Colorado.

Table 6. Production per occupied territory, nesting attempt and success of ferruginous hawks in 1972 and 1973.

	Young fledged per occupied territory	Young hatched per		Young fledged per	
		Nesting attempt	Successful nest	Nesting attempt	Successful nest
1972	1.89	2.33	2.87	2.21	2.70
1973	1.03	2.14	2.56	2.03	2.34

Food Habits During Nesting Season

I collected 197 prey items from ferruginous hawk nests in 1972 and 1973. In 1972, 42 prey items were identified from 19 nests, while in 1973, 133 items from seven nests were identified. An additional 20 items came from nine other nests visited during banding operations in 1973. Based on percent frequency of occurrence mammal species represented 90.4 percent of the total prey items, while birds and reptiles constituted 6.1 and 3.4 percent, respectively. Remains of six species of birds and three species of lizards were identified (Table 7). This study corroborated the observations of Cameron (1914), Angell (1968), Olendorff (1973) and Smith and Murphy (1973) that birds taken as prey were primarily recent fledglings.

The data indicate that the northern pocket gopher is a major prey item, as it comprised 43.2 percent of the mammals and 41.1 percent of all prey items. Black-tailed jackrabbits accounted for 29.8 percent of the mammals. Total utilization of mammals was 97.6 and 83.3 percent during 1972 and 1973, respectively.

When species utilization was considered on the basis of biomass for the three major prey species during 1972 and 1973, jackrabbits comprised 88.7 and 79.4 percent, respectively. Pocket gophers represented 5.4 and 6.6 percent during the respective years, while ground squirrels accounted for 4.2 and 6.6 percent (Figure 2). Although pocket gophers were the most numerous in a frequency count, jackrabbits were the most important prey item based on biomass. Smith and Murphy (1973) corroborate the importance of jackrabbits as a major food source. In

Table 7. Analysis of prey found in ferruginous hawk nests in 1972 and 1973.

	1972		1973		Total	
	No.	%	No.	%	No.	%
Mammals	41	97.6	129	83.3	170	90.4
Specific analysis for mammals						
Northern pocket gopher (Thomomys talpoides)	16	39.0	55	44.7	71	43.3
Black-tailed jackrabbit (Lepus californicus)	15	36.0	34	27.6	49	29.8
Townsend ground squirrel (Spermophilus townsendi)	5	12.1	24	19.5	29	17.6
Ord kangaroo rat (Dipodomys ordi)	0	0	4	3.2	4	2.4
Pygmy rabbit (Sylvilagus idahoensis)	1	2.4	2	1.6	3	1.8
Mountain cottontail (Sylvilagus nuttalli)	2	4.8	0	0	2	1.2
Shorttail weasel (Mustela erminea)	1	2.4	1	.8	2	1.2
White-tailed jackrabbit (Lepus townsendi)	0	0	1	.8	1	.6
Least chipmunk (Eutamias minimus)	1	2.4	0	0	1	.6
Mountain vole (Microtus montanus)	0	0	1	.8	1	.6
Sagebrush vole (Lagurus curtatus)	0	0	1	.8	1	.6
Total	41	99.6	123	99.8	164	99.7
Birds	0	0	19	12.2	19	6.1
Western meadowlark (Sturnella neglecta)						
Horned lark (Eremophila alpestris)						
Black-billed magpie (Pica pica)						
Short-eared owl (Asio flammeus)						
Sage grouse (Centrocercus urophasianus)						
Ring-necked pheasant (Phasianus colchicus)						
Reptiles	1	2.4	7	4.5	8	3.4
Desert horned lizard (Phrynosoma platyrhinos)						
Leopard lizard (Crotaphytus wislizeni)						
Western whiptail (Cnemidophorus tigris)						
TOTAL PREY ITEMS	42	100.0	155	100.0	197	99.9

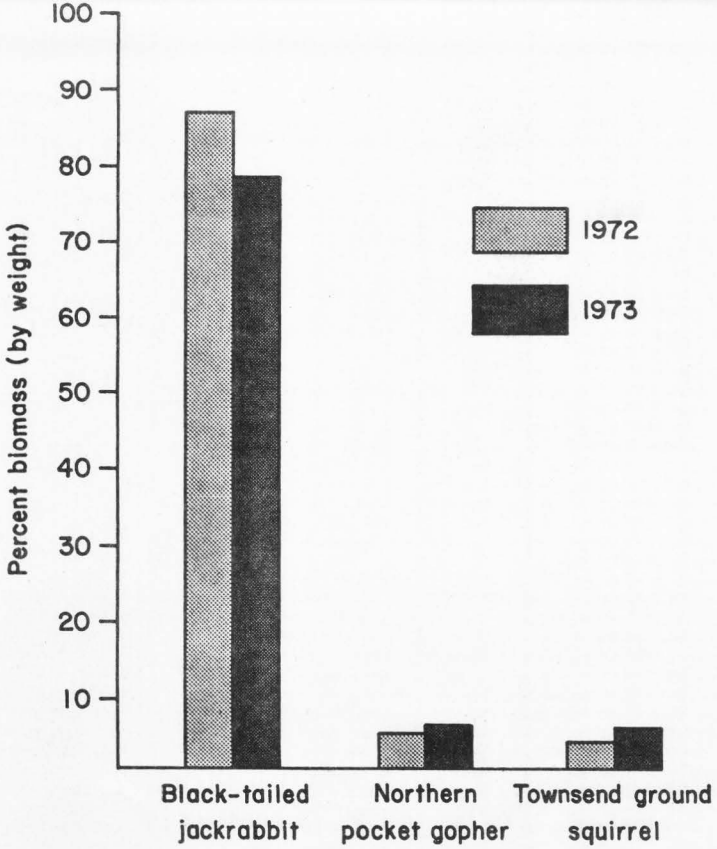

Figure 2. Changes in biomass of major prey species found in ferruginous hawk nests, 1972 and 1973.

west central Utah, jackrabbits represented 95.0 and 93.0 percent of the total biomass of prey in 1969 and 1970, respectively.

Another aspect of biomass was observed in relation to growing young. Jackrabbits first occurred during mid May in both years as prey items. Ten jackrabbits were found in nests during this period; five were young rabbits about four weeks old. In June, two young jackrabbits were identified while 22 adult and immature rabbits were found. In July, this number decreased to 19 adult and immature rabbits. The data indicate ferruginous hawks may not be preying upon rabbits intensively until the young are into the exponential phase of their growth period; a period requiring large quantities of food. Reasons for jackrabbits occurring later in the diet may be that the female, a larger bird, hence more capable of taking jackrabbits, is released from her roles of incubating and brooding.

Since raptors tend to take prey in proportion to prey densities (Craighead and Craighead 1956) and jackrabbits constitute a major food source for ferruginous hawks in this study area (Table 7; Platt 1971:60), low jackrabbit densities may have been a major factor in the reduced breeding success during 1973. Jackrabbit density estimates reported by Stoddart (Appendix B) corroborate this possibility. In the spring of 1972, mean jackrabbit density for Curlew Valley was 47.1/km^2 as compared to 9.7/km^2 in the spring of 1973. These figures indicate a precipitous decline of 79 percent.

Luttich et al. (1970) observed considerable flexibility in the food habits of red-tailed hawks (Buteo jamaicensis) in Alberta, Canada and concluded that the hawks shift predation intensity to the more available

species. The shift was induced either by an increase or scarcity of a given prey species.

Food habits information was obtained from two discrete habitat types in Curlew Valley. Three nests in desert shrub vegetation and four in crested wheatgrass-alfalfa complexes were visited and prey items and pellets were collected every four days until the young fledged. Totals of 46 and 87 prey items were identified from each type. Northern pocket gophers constituted 57.4 percent of the prey items in the crested wheatgrass type on a frequency basis, while black-tailed jackrabbits comprised 3.4 percent. In the desert shrub type, 67.3 percent of the prey items were jackrabbits. No pocket gophers were found (Table 8). Jackrabbit densities in Curlew Valley as estimated by Stoddart and Anderson (1972b) ranged from 2.6 to 3.0 per hectare in sagebrush types and 0 to 1.0 per hectare in crested wheatgrass types. This indicates that the hawks' food habits are influenced by the abundance of various prey species in a given habitat type.

Sexing Criteria and Growth Rates

Sexual dimorphism, in which females are larger than males, occurs in many species of raptors (Brown and Amadon 1968). Kochert (1972) suggested foot pad length measurement as a method for determining sex in golden eagles (Aquila chrysaetos). Olendorff (1971) suggested a possible sexing method for ferruginous hawks by determining the ratio of bill length to bill width.

In this study both body weight and flexed hallux size (Figure 3) were used as indices for sexing birds. Birds that weighed the most also had the largest hallux diameters. In 1972 and 1973, hallux sizes and

Table 8. Frequency of prey species from seven nests located in desert shrub and crested wheatgrass-alfalfa vegetation types.

Species	Desert shrub		Crested wheatgrass-alfalfa	
	No.	Percent	No.	Percent
Northern pocket gopher	0	0	50	57.4
Black-tailed jackrabbit	31	67.3	3	3.4
Townsend ground squirrel	2	4.3	18	20.6
Ords kangaroo rat	4	8.6	0	0
Pygmy rabbit	1	2.1	1	1.1
Shorttail weasel	1	2.1	1	1.1
Sagebrush vole	0	0	1	1.1
Mountain vole	0	0	1	1.1
Birds	3	6.5	10	11.4
Reptiles	4	8.6	2	2.2
Total	46	99.5	87	99.4

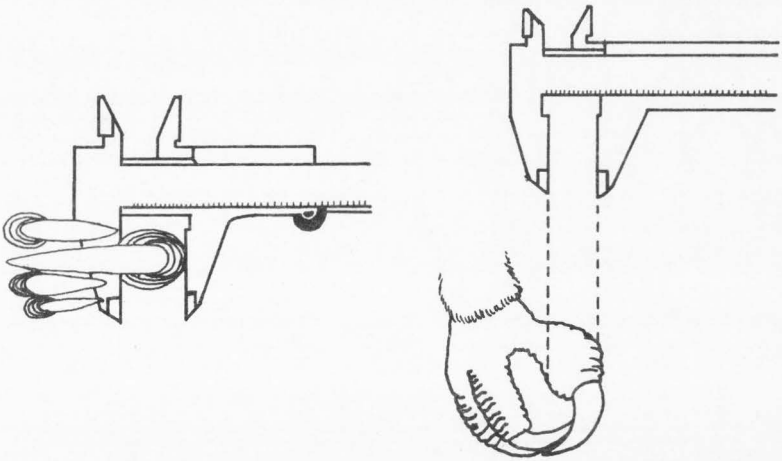

Figure 3. Illustration of how to measure flexed hallux.

weights were recorded for 49 birds whose hatching dates were known within one day. After the young attained an age of 30 days a T test (T=2.681, P .01, df=48) showed a statistically significant difference of hallux size and body weight. Individuals with the greater hallux size and body weights were considered females. Mean flexed hallux diameters for 26 females and 23 males were 17.5 (s.e. ± .8) mm and 13.9 (s.e. ± .9) mm respectively (Figure 4). Mean weights of 26 females and 23 males were 1477.3 (s.e. ± 20.9) g and 1030.4 (s.e. ± 22.2) g, respectively (Figures 5 and 6). Mean weights for females and males were slightly lower than those recorded by Imler (1937). In that study, two males averaged 1237 g and three females averaged 1983 g. In his study, sex was determined by plumage and weight. The average weight of three females and two males recorded by Olendorff (1971) is comparable to my data. At 46 days, the females averaged 1354 g and the males averaged 1060.5 g.

Olendorff (1972) described growth curves for ferruginous hawks under laboratory conditions and found that the growth curve was best fitted with a logistic equation. In this study, several non-linear models were tested but the growth data was best fitted by the quadratic equation in the following generalized form:

$$Y = a+b_x+c_x2+d_x3$$

The equation was first calculated using all four terms. However, when the terms d_x3 and c_x2 were eliminated for males and females respectively, the equation provided a better fit to the data.

The equation describes three of four stages recorded by Olendorff (1971). The lag phase (Olendorff's first stage) following hatching wasn't observed in this study. The general form of the growth curve can be defined in three stages: (1) the logarithmic phase of maximum

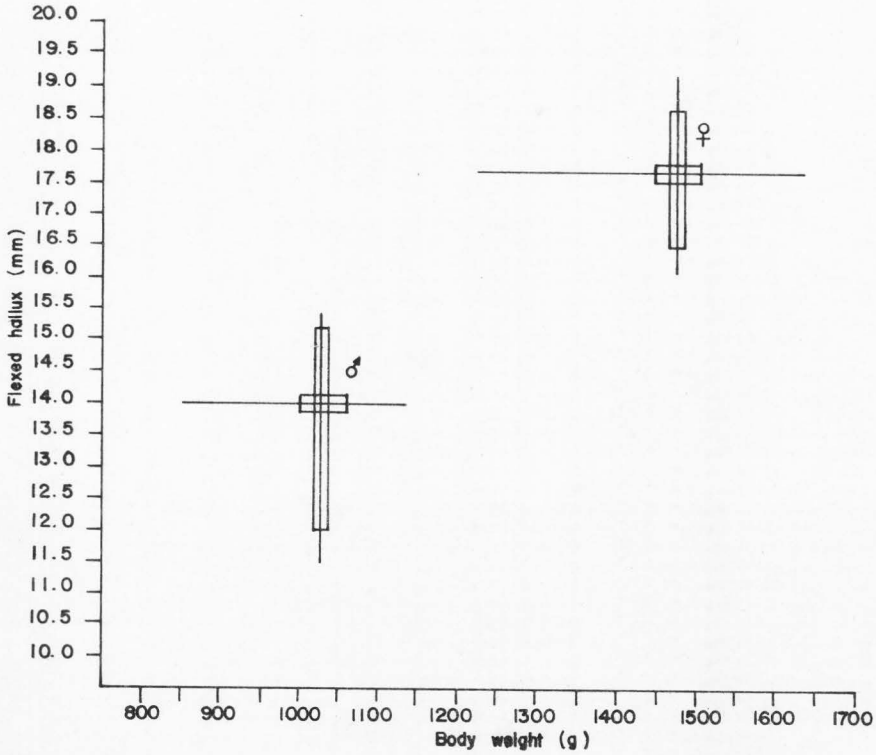

Figure 4. Relationship of flexed hallux and body weights of 49 nestling ferruginous hawks. The horizontal and vertical lines and boxes represent the sample ranges and 90 percent confidence limits respectively.

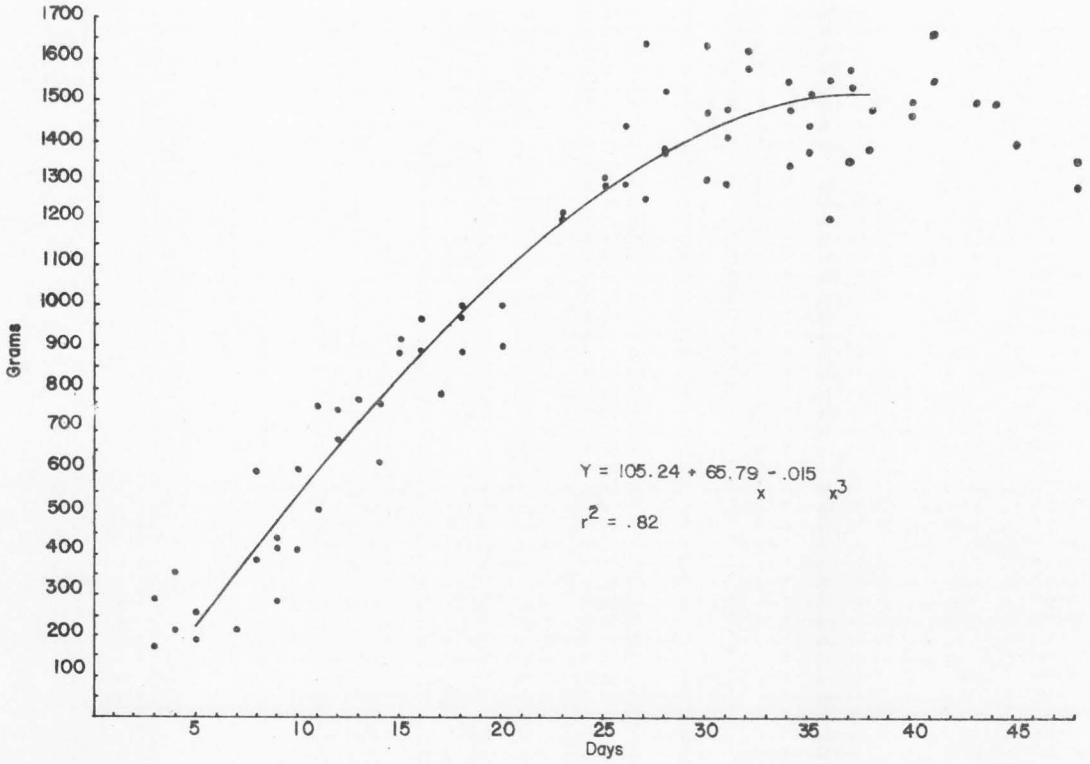

Figure 6. Weights of 26 nestlings considered to be females.

growth rate (5-27 days); (2) the decay phase where rate of growth decreases (28-36 days); and (3) the asymptotic phase during which a reduced growth rate is masked by body weight fluctuations (37-45 days).

The growth constants from day 12 through day 30 were higher with free-living birds than those observed by Olendorff (1971) for five hand-reared birds. During this period in the present study, growth of both sexes was five to seven days faster. For example, where females averaged 521 g on day 15 in Olendorff's study, the data in this study showed that females averaged 535 g on day 10 (Appendix C and D).

Additional data from internally sexed birds is necessary to validate the observed hallux size and weight differential between male and female ferruginous hawks. However, the results of this study indicate that unfledged birds more than 30 days old with a flexed hallux greater than 16.1 mm and a weight greater than 1219 g are females.

Melanism

Three distinct plumages of ferruginous hawks were observed in the study area: (1) light, (2) melanistic, and (3) immature. Brown and Amadon (1968) describe light, red, black and immature plumages. The black phase has a body colored by clove brown or sepia with the wings and tail like the light phase. The red phase is similar to the black phase but more rufous. The red phase is not readily identifiable unless the bird can be observed through a spotting scope. No red phase birds were observed in the present study.

Of 104 adults, 3.5 percent (4) were melanistic and 96.5 percent (100) were light phase (Table 9). All observed dark phase adults in the study area were paired with light phase birds during 1972 and 1973.

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None of the light phase pairs produced melanistic young. Olendorff (1973) found that three percent of the adult population in northeastern Colorado was melanistic. Weston (1969) recorded one melanistic adult paired with a light phase bird in Cedar Valley, Utah. Bent (1937) noted dark phase birds in Saskatchewan were mated with light phase birds.

Table 9. Incidence of melanism in ferruginous hawks in Curlew and Raft River Valleys.

	1972	1973	Total	Percent
Light-phase adults	59	41	100	96.5
Melanistic adults	3	1	4	3.5
Light-phase young	81	55	136	92.5
Melanistic young	8	3	11	6.5
females	3	-		
males	5	3		

Mortality Factors

Nine dead ferruginous hawks were recorded during this study; immature fledglings comprised 47 percent (Table 10). Salt and Wilk (1958) reported that of 144 young ferruginous hawks banded in Alberta, Canada, 19 percent (28 band returns) died before they were ten months old. Brown and Amadon (1968) note that the young of many species of

raptors may suffer as much as 60 percent mortality during the first year. In Scotland, Olsson (1958) estimated first-year mortality in common buzzards (Buteo buteo) at 65 percent.

Table 10. Age class and percent mortality of ferruginous hawks in the study area from 1971 to 1973.

Year	Age in weeks 1-2	3-5	6-8	8+	Adult	Total
1971				2		2
1972	3	1	1	3	1	9
1973	-	2	-	3	1	6
Totals	3	3	1	8	2	17
Percent	18	18	5	47	12	100

Mortality caused by humans was the major factor in my study area. The demise of four immature birds and one adult was attributable to humans (Tables 11 and 12). In 1971, a gravel pit located in the study area was used to dump tar from the bilge of a truck. Numerous mammals and birds were found dead in the tar, including one immature ferruginous hawk. Two other immature birds were found along roadsides, one in 1971 and the other in 1972, both apparently hit by vehicles. Road-killed prey present an easy food source for recently fledged raptors. During 1971 and 1972, 26 observations were made of young ferruginous hawks eating dead jackrabbits on roads. Due to scarcity of jackrabbit roadkills, no roadside feeding occurrences were seen in 1973. In 1972,

one fledgling which had been shot in the head was found 0.8 km from its nest. In 1973, one adult which had been shot through the chest was found at the base of a fence post. Cause of mortality was not indicated for four of the five band return reports received in 1972 and 1973. However, one report from Mexico indicated the bird had been shot.

Circumstantial evidence indicated great horned owls (Bubo virinianus) caused some mortality among nestlings. Craighead and Craighead (1956) noted that great horned owls tend to dominate a nesting population of raptors. It is the earliest nester, causes nest desertion by its presence and actively preys on other raptors. Great horned owls were observed in the vicinity of two ferruginous hawk nests where mortality occurred. In 1972, an injured adult female and one dead nestling were found at one nest site. The adult died a day later. Subsequent examination revealed perforations in the chest and shoulder area of both birds. Two young remaining in the nest were successfully raised by the male.

In 1973, a dead male nestling was found at the base of its nest tree. Two live young were in the nest, but the adults were not seen in the vicinity. One possible explanation is that both adults were forced to hunt far from the nest vicinity due to low prey density in an area where they could not observe intruders. Necropsy of the dead nestling, performed by Dr. Steve Mullin (1974), a veterinarian, suggested death due to starvation. In every nest visit made in 1972 and all except three in 1973, adults were present. Ingram (1959) found fratricide occurring frequently in raptors. Observations during this study did not indicate the occurrence of fratricide.

Table 11. Probable cause of mortality of 11 ferruginous hawks in 1971 and 1972.

Date	Age class	Probable cause of mortality	Comments
1. 8/27/71	8+ weeks	human	Bird found stuck in Utah Highway Department tarpit.
2. 9/20/71	8+ weeks	human	Road killed by vehicle.
3. 5/28/72	1-2 weeks	possibly predator	Missing from the nest. No evidence of removal by man.
4. 5/28/72	1-2 weeks	possibly predator	Missing from the nest. No evidence of removal by man.
5. 5/28/72	1-2 weeks	possibly predator	Missing from the nest. No evidence of removal by man.
6. 6/14/72	6-7 weeks	predator	Necropsy suggests great horned owl.
7. 6/23/72	3-5 weeks	predator	Necropsy suggests great horned owl.
8. 6/24/72	adult	predator	Necropsy suggests great horned owl.
9. 7/16/72	8+ weeks	human	Bird shot through the head.
10. 7/30/72	8+ weeks	human	Road killed by vehicle.
11. 9/20/72	8+ weeks	unknown	Found in the vicinity of Howe, Idaho.

Table 12. Probable cause of mortality of six ferruginous hawks in 1973.

Date	Age class	Probable cause of mortality	Comments
1. 2/5/73	8+ weeks	shot	Found in the vicinity of Hermosillo, Mexico.
2. 2/23/73	8+ weeks	unknown	Found in the vicinity of Ipswich, South Dakota.
3. 2/ /73	8+ weeks	unknown	Found in the vicinity of Shallowater, Texas.
4. 6/8/73	adult	human	Shot through the chest.
5. 6/17/73	3-5 weeks	predator	Necropsy suggests great horned owl.
6. 6/23/73	3-5 weeks	starvation	Emaciated pectoral muscles.

Myiasis was observed in the ear orifices of six nestling ferruginous hawks. Of 15 nests examined, 74 percent were infected with botfly larvae (Protocaliferia asiovora) (Whitworth 1973). No deaths of nestlings were attributed to myiasis. White (1963) recorded a high mortality of nestling prairie falcons (Falco mexicanus) in Utah due to myiasis. Kochert (1971) observed trichomoniasis and aspergillosis in golden eagles. No cases of either disease were observed in the ferruginous hawks examined in this study.

Habitat Preferences

Of 97 nest sites, 92 (95 percent) were located in juniper trees and three (3 percent) on the ground in sagebrush communities. One nest was built in a narrowleaf cottonwood (Populus angustifolia) and another built on the crossarms of a utility pole. Platt (1971) suggested that ferruginous hawks in Curlew Valley may utilize two types of nest sites. Ground nesting would distribute them evenly, while juniper nesting would cluster them. Of three ground nest attempts in the Curlew and Raft River Valleys, only one was successful.

Rolfe (1896) found ferruginous hawks nesting in trees and on bleak, stone-covered hills in North Dakota. Bowles and Decker (1931) reported nests in Washington located on small rock outcrops on the slopes of steep hillsides or occasionally in small trees such as junipers or locust (Robinia pseudacacia). Weston (1969) noted that in Cedar Valley, Utah, 41 percent nested in junipers, while 52 percent nested on the ground. Incidence of ground nesting was six percent on the Pawnee National Grassland, Colorado (Olendorff 1972).

Predominant habitat types for 1972 and 1973 were desert shrub and crested wheatgrass treatments for the 63 nests examined (Table 13). The relative percentages of shrub and crested wheatgrass in the vicinity of nests was reversed in 1973 as compared to 1972. This may reflect the influence of several variables. As noted previously, food-habit analysis indicated jackrabbits as a major prey item in the ferruginous hawks' diet. Several investigators have reported that jackrabbits favor habitats which provide an interspersion of tall cover with open spaces (Taylor and Lay 1944; Lechleitner 1958). Westoby and Wagner (1973) found that jackrabbit use of crested wheatgrass seedings was concentrated around the edge of such areas in Curlew Valley.

It appears that in 1973, ferruginous hawks produced more young if a high percentage of crested wheatgrass interspersed with desert shrub was present within their hunting territory. Crested wheatgrass treatments in various stages of succession may increase the probability that adults will produce young during years of low jackrabbit densities due to the greater abundance of prey in these areas. However, a T-test revealed no significant difference between the relative percentages of crested wheatgrass in the vicinity of successful nests in 1972 and 1973, probably as the result of small sample sizes. These conclusions are not universally applicable, since ground squirrels make up the major biomass of prey taken in other areas and a different situation may exist (Olendorff 1973; Fyfe 1973). Additional data are needed to substantiate this interpretation.

No nest sites occurred in cultivated areas, although a trace of intensive agriculture was found in the vicinity of one nest. Rolfe (1896), Taverner (1934) and Olendorff (1972) maintain that cultivation

Table 13. Percent composition of plant types within a 763-meter radius of ferruginous hawk nest sites.

	No. of nests	Percent Composition: Desert shrub	Crested wheatgrass	Juniper	Alfalfa	Cereals
1972						
Attended nests	21	49	44	7	-	.004
Nests with eggs	5	57	24	17	1	-
Nests with young	14	53	32	13	1	-
TOTAL NESTS	31	52	35	11	.06	trace
1973						
Attended nests	11	54	41	5	-	.004
Nests with eggs	5	49	39	12	-	-
Nests with young	16	32	56	9	4	-
TOTAL NESTS	32	42	48	8	2	trace

has a detrimental impact on the nesting habitat of ferruginous hawks. Of 71 nestlings raised in northeastern Colorado, only one (1.4 percent) was successfully raised in a cultivated situation (Olendorff 1972).

SUMMARY AND CONCLUSIONS

In a cooperative effort with Leon Powers of Idaho State University, I surveyed the Curlew and Raft River Valleys for breeding pairs of ferruginous hawks. Objectives of the study were to: (1) ascertain nesting density and breeding success; (2) document food habits; (3) determine weight gained by the nestlings; (4) identify mortality factors; and (5) analyze vegetation around nests. Forty-three and 54 pairs were found attending nests during 1972 and 1973 respectively. The following conclusions were drawn from the two-year study on breeding pairs of ferruginous hawks in Curlew and Raft River Valleys:

1. An observed increase in area for successful nests when compared to nesting attempts in 1972 and 1973 may reflect the territorial limits of paired birds for each year dependent upon prey abundance.

2. Thirty-one pairs were successful at fledging young during 1972 while 23 fledged young in 1973.

3. Mean clutch size was 2.78 in 1972 and 2.77 in 1973.

4. Earliest laying date in 1972 was 26 March as compared to 3 April in 1973.

5. Fledging dates ranged from 14 June to 14 July in 1972. Comparable dates for 1973 were 20 June to 18 July.

6. Human disturbance during the incubation period resulted in abandonment of five nests. No nests were abandoned after the young hatched.

7. Young fledged per occupied territory and per successful nest were 1.89 and 2.70 respectively in 1972. Comparable figures for 1973 were 1.03 and 2.34.

8. Major prey items, based on biomass, were black-tailed jackrabbits, northern pocket gophers and Townsend ground squirrels.

9. Within the study area, total number of young produced per year may be related to jackrabbit densities.

10. Unfledged birds more than 30 days old with a flexed hallux greater than 16.1 mm and a weight above 1219 g are probably females.

11. Mean weights of 26 females and 23 males were 1477.4 g and 1030.4 g, respectively.

12. Incidence of melanism was 3.5 percent in the adult population and 6.5 percent in the young.

13. Of 17 dead ferruginous hawks, 47 percent were immature birds.

14. Of 97 nest sites, 95 percent were located in juniper trees.

15. Composition of dominant vegetative types was desert shrub and crested wheatgrass in various stages of reversion to sagebrush.

RECOMMENDATIONS

Results of this study indicate that ferruginous hawks breed in remote areas. Nationally, the status of this species is unknown but in such areas as the Curlew and Raft River Valleys they are present in substantial numbers. Much of the breeding range of this species is administered by the Bureau of Land Management. A concerted effort should be made by BLM personnel in the near future to survey such places where ferruginous hawks might be breeding. Such a survey should be conducted when young are in the nest during the first part of June.

Present nesting habitat of ferruginous hawks in Curlew and Raft River Valleys may be threatened. Proposed land uses such as geothermal exploitation and conversion of large tracts of land into intensive agriculture present problems. Increased disturbance, loss of habitat for nesting sites and reduction in major prey populations could markedly affect ferruginous hawk density and breeding success. Annual spring censuses of the study area and monitoring of the population are necessary.

During the incubation period, ferruginous hawks appear to be sensitive to human activity. Pairs may abandon their nests even after a single nest visit. Habitat manipulation such as juniper chaining and discing can be detrimental. If such treatments are employed where hawks are nesting, these activities should be delayed until young hawks fledge. Where treatments cannot be delayed and young hawks are present in the nest, the young may be transferred to another active nest with young of similar size. If an active ferruginous hawk nest cannot be found, young may be transferred to an active Swainson's or red-tailed hawk nest.

Where treatments cannot be delayed and eggs are present in the nest, that clutch will have to be sacrificed. The clutch should not be transferred to another nest containing eggs because of the high probability of causing the "foster" adults to desert.

Alteration of habitat by chaining can be an effective method of enhancing prey base (Baker and Frischknecht 1973). A pattern of treating small tracts of land, creating many interspersion areas, will be more beneficial than treating the same area in large blocks. In the case of crested wheatgrass plantings, a minimum of 20 percent of the total area should be left in its present stage of succession in the form of islands scattered throughout the treated area. Results from the present study indicate that past crested wheatgrass plantings have not adversely affected reproduction of ferruginous hawks. Succession occurring in these areas has made the area suitable for nesting within a period of six to eight years following the treatment. Using the plan suggested above, this period may be reduced to three or four years following the treatment. Where juniper communities are chained, nesting habitat can be enhanced by thinning the trees along the perimeter of the chained area.

LITERATURE CITED

American Birds. 1972. The Blue List for 1973. 26(6):932-933.

American Ornithologists' Union. 1957. Checklist of North American Birds. The Lord Baltimore Press, Inc., Baltimore, Maryland. 691 pp.

Angell, T. 1969. A study of the ferruginous hawk: adult and brood behavior. The Living Bird 8:225-241.

Baker, M. F., and N. C. Frischknecht. 1973. Small mammals increase on recently cleared and seeded juniper rangeland. J. of Range Manage. 26(2):101-103.

Bendire, C. E. 1892. Life histories of North American birds. U. S. Natl. Mus. Spec. Bull. 1:259-262.

Bent, A. C. 1937. Life histories of North American birds of prey. Bull. U. S. Natl. Mus. 167:284-293.

Bowles, J. H., and F. Decker. 1931. The ferruginous rough-leg in Washington. Murrelet 12(3):65-70.

Brown, L. H., and D. Amadon. 1968. Eagles, hawks and falcons of the world. McGraw-Hill Book Company, Inc., New York. 945 pp.

Brown, L. H., and A. Watson. 1964. The golden eagle in relation to its food supply. Ibis 106:78-100.

Cameron, E. S. 1914. The ferruginous rough-leg in Montana. Auk 31: 159-167.

Craighead, J. J., and F. Craighead. 1956. Hawks, owls and wildlife. The Stackpole Co., Harrisburg, Penn. 443 pp.

Cronquist, A., R. Holmgren, N. Holmgren, and J. Reveal. 1972. Intermountain Flora, Vol. I. Hafner Publishing Co., New York. 270 pp.

Fyfe, R. 1974. Personal communication. Canadian Wildlife Service, Edmonton, Alberta, Canada. January 11.

Imler, R. H. 1937. Weights of some birds of prey of western Kansas. Bird Banding 8(4):166-170.

Ingram, C. 1959. The importance of juvenile cannibalism in breeding biology of certain birds of prey. Auk 76:218-226.

Kochert, M. N. 1972. Population status and chemical contamination in golden eagles in southwestern Idaho. Unpubl. M. S. Thesis, University of Idaho, Moscow. 102 pp.

Lechleitner, R. R. 1958. Certain aspects of behavior of the black-tailed jackrabbit. Amer. Midl. Natur. 60:145-155.

Luttich, S. N., D. H. Rusch, E. C. Meslow, and L. B. Keith. 1970. Ecology of red-tailed hawk predation in Alberta. Ecology 51:190-203.

Mitchell, J. E. 1965. Relationship between soil mineralogy and plant distribution within two communities of the shadscale zone in Utah. M. S. Thesis, Utah State Univ., Logan, Utah 68 pp.

Mullin, S. 1974. Personal communication. Utah State Univ. June.

Odum, E. P. 1959. Fundamentals of ecology. W. P. Saunders, Philadelphia, Penn. 546 pp.

Olendorff, R. R. 1971. Morphological aspects of growth of three species of hawks. Unpubl. PhD dissertation, Colorado State Univ., Fort Collins. 460 pp.

Olendorff, R. R. 1972. The large birds of prey of the Pawnee National Grassland: nesting habits and productivity. U. S. I. B. P. Grassland Biome Tech. Rep. No. 151, Colorado State Univ., Fort Collins. 59 pp.

Olendorff, R. R. 1973. The ecology of the nesting birds of prey of northeastern Colorado. U. S. I. B. P. Grassland Biome Tech. Rep. No. 211, Colorado State Univ., Fort Collins. 233 pp.

Olsson, V. 1958. Dispersal, migration, longevity and death causes of Buteo buteo et al. Acta Vertebratica 1:91-189.

Oregon State Univ. Agri. Exper. Station. 1969. Endangered Plants and Animals of Oregon. III. Birds. Spec. Rep. No. 278. Corvallis. pp. 9-10.

Platt, J. B. 1971. A survey of nesting hawks, eagles, falcons and owls in Curlew Valley, Utah. Great Basin Naturalist 31(2):51-65.

Platt, J. B. 1973. Personal communication. Brigham Young Univ. August.

Porter, R. D. 1951. The status of rough-legged hawks in Idaho. Condor 53(5):257-258.

Powers, L. R., R. Howard, and C. Trost. 1973. Population status of the ferruginous hawk in southeastern Idaho and northern Utah. Conference on raptor conservation techniques. In press. Colorado State Univ., Fort Collins.

Renn, F. 1973. Personal communication. Idaho State Univ. June.

Rolfe, E. S. 1896. Nesting of the ferruginous rough-leg. Osprey 1:8-10.

Salt, W. P. 1939. Notes on the recoveries of banded ferruginous rough-legged hawks. Bird Banding 10:80-84.

Salt, W. R., and A. L. Wilk. 1958. Birds of Alberta. Queen's Printer, Edmonton, Alberta, Canada. 511 pp.

Scheffer, T. H. 1941. Ground squirrel studies in the Four-Rivers Country, Washington. J. Mammal. 22:270-279.

Smith, D. G., and J. Murphy. 1973. Breeding ecology of raptors in the eastern great basin of Utah. Brigham Young Univ. Sci. Bull., Biol. Ser. 18(3):76 pp.

Stoddart, L. C. 1972. Population biology of northern Utah black-tailed jackrabbits. PhD Thesis. Utah State Univ., Logan, Utah. 134 pp. Univ. Microfilms, Ann Arbor, Mich.

Stoddart, L. C. 1974. Personal Communication. Utah State Univ., January.

Stoddart, L. D., and R. D. Anderson. 1972. Biomass density of lagomorphs. U. S. I. B. P. Curlew Valley Validation Site Report. No. RM72-1. 188 pp.

Taylor, W. P., and D. W. Lay. 1944. Ecologic niches occupied by rabbits in eastern Texas. Ecology 25:120-121.

Taverner, P. A. 1934. Birds of Canada. Natl. Mus. of Canada. Biol. Ser. No. 19, Bull. 72. Ottawa, Ontario. 445 pp.

Turner, G. T., R. M. Hansen, V. H. Reid, H. P. Teitjen, and A. L. Ward. 1973. Pocket gophers and Colorado mountain rangeland. Colorado State Univ. Exper. Sta. Bull. 5545. Fort Collins. 90 pp.

U. S. Department of the Interior. 1968. Rare and Endangered Fish and Wildlife of the United States. Resource Publication 34. Government Printing Office, Washington, D. C.

Westoby, M., and F. H. Wagner. 1973. Use of a crested wheatgrass seeding by black-tailed jackrabbits. J. Range Manage. 26(5):349-352.

Weston, J. B. 1968. Nesting ecology of the ferruginous hawk Buteo regalis. Unpubl. M. S. Thesis, Brigham Young Univ., Provo, Utah. 40 pp.

Weston, J. B. 1969. Nesting ecology of the ferruginous hawk Buteo regalis. Brigham Young Univ. Sci. Bull., Biol. Ser. 10(4):25-34.

APPENDICES

Appendix A

Table 14. Observed status of birds of prey in the study area.

	Status				
	Spring	Summer	Fall	Winter	
Golden eagle (Aquila chrysaetos)	N	P	P	P	(1,2,3)
Bald eagle (Haliaeetus leucocephalus)	A	A	A	P	(1)
Ferruginous hawk (Buteo regalis)	N	P	P	P	(1,2,3)
Redtailed hawk (Buteo jamaicensis)	N	P	P	P	(1,2,3)
Swainson's hawk (Buteo swainsoni)	N	P	P	A	(1,2,3)
Rough-legged hawk (Buteo lagopus)	N	A	P	P	(1,3)
Prairie falcon (Falco mexicanus)	N	P	P	P	(1,2,3)
American kestrel (Falco sparverius)	N	P	P	P	(1,2,3)
Merlin (Falco columbaris	P	A	A	A	(3)
Goshawk (Accipiter gentilis)	P	A	P	P	(1,2,3)
Cooper's hawk (Accipiter cooperii)	N	P	P	A	(2,3)
Sharp-shinned hawk (Accipiter striatus)	N	P	P	A	(2,3)
Marsh hawk (Circus cyaneus)	N	P	P	P	(1,2,3)
Great horned owl (Bubo virginianus)	N	P	P	P	(1,2,3)
Short-eared owl (Asio flamneus)	N	P	P	P	(1,2,3)
Burrowing owl (Speotyto cunicularia)	N	P	P	A	(1,2,3)
Long-eared owl (Asio otus)	N	P	P	A	(1,2,3)
Barn owl (Tyto alba)	N	P	P	A	(2,3)
Screech owl (Otus asio)	P	P	A	A	(2)
Turkey vulture (Cathartes aura)	N	P	P	A	(1,2,3)
Raven (Corvus corax)	N	P	P	P	(1,2,3)

N=nests in area; P=present in area; A=absent from area.
Numbers refer to investigators as follows: 1=Leon Powers and Richard Howard (1971-1973); 2=Joe Platt (1969); 3=Frank Renn (1969 and 1970).

Appendix B

Table 15. Spring and fall densities of jackrabbits per square mile and square kilometer from 1968 to 1973 (Stoddart 1974).

Year	Spring No./mi^2(km^2)	Fall No./mi^2(km^2)
1968	13.2 (5.1)	92.6 (35.8)
1969	61.7 (23.8)	176.0 (68.0)
1970	96.0 (37.1)	264.0 (102.0)
1971	182.0 (70.3)	225.4 (87.0)
1972	122.1 (47.1)	89.3 (34.5)
1973	25.2 (9.7)	19.6 (7.6)

Appendix C

Table 16. Body weight in grams of 23 ferruginous hawks considered to be males.

Age	Weight					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
1	71					
2						
3	170					
4	184					
5	156	255				
6	213					
7	213					
8	383					
9	283	411	439			
10	411	468	468	496	496	609
11	467	510	666	454		
12	454	694	765			
13	524	539	822			
14	539	595				
15	468	595	609	638	638	
16	567	624	666	780		
17	581	638	652	723	822	
18	723	780				
19	794	865				
20	978					
21	964	624				
22	808	865	950	1021		
23	950					
24	950	879				
25	992	992	1021			
26	964	964	978			
27	893	964	978	1006		
28	978	978				
29	751	935	978	1035	1134	1205
30	992	1035	1049	1073	1106	1106
31	1035	1094	1134			
32	912	1063	1148			
33	1049					
34	751					
35	1134					
36	1035	1049				
37	1021	1063				
38	907	1134				
39	1021	1035				
40	850	1035	1120			
41	935	1021	1073			
42	978					
43	1021	1063				
44	978					
45	1021					
46	1035					

Appendix D

Table 17. Body weight in grams of 26 ferruginous hawks considered to be females.

Age	Weight				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	70				
2					
3	171				
4	213				
5	184	255			
6					
7	212				
8	383				
9	283	411	439		
10	411	609			
11	510	751			
12	680	751			
13	723	780			
14	624	765			
15	893	921			
16	921	978			
17	794				
18	893	978	1006		
19					
20	907	1006			
21					
22					
23	1219	1233			
24					
25	1318				
26	1304	1318	1446	1446	
27	1262	1644			
28	1389	1389	1531		
29					
30	1318	1488	1644		
31	1304	1417	1488		
32	1588	1630			
33					
34	1437	1488	1559	1559	1559
35	1389	1446	1517	1531	
36	1219	1573			
37	1361	1545	1588		
38	1389	1488			
39					
40	1474	1502			

Table 17. Continued

Age	Sample 1	Sample 2	Weight Sample 3	Sample 4	Sample 5
41	1559	1673			
42					
43	1502				
44	1247	1488			
45					
46					
47					
48	1361				

Appendix E

Table 18. Hallux diameter in millimeters of 23 male and 26 female ferruginous hawks from 30 days of age to fledgling.

Age	Males Sample 1	Sample 2	Sample 3	Sample 4
30	13.1	13.8	14.3	15.0
31	13.7	15.3		
32				
33	14.0			
34				
35	15.2			
36	13.2	14.0		
37	11.4	14.0		
38	15.4			
39	13.9			
40	12.7	13.8	15.1	
41	14.4			
42	14.2			
43	13.4			
44	13.7			
45	14.1			
46	13.8			

Age	Females Sample 1	Sample 2	Sample 3	Sample 4
30	16.3	19.2		
31	16.8			
32	16.9	17.9		
33				
34	16.6	16.6	17.0	17.9
35	17.1	16.4		
36	16.1	18.0		
37	16.8	17.8	16.6	
38	16.3	19.2		
39				
40	16.6	19.2		
41	17.4	19.2		
42				
43	18.1			
44	18.5	18.9		
--				
--				
48	17.9			

Appendix F

Table 19. Percent composition of plant types within a 763 meter radius of 63 ferruginous hawk nests, 1972 and 1973.

Nest No. (1972)		Desert shrub	Crested wheatgrass treatment	Juniper	Alfalfa	Cereals
Curlew Valley						
1.3	A*	50	32	19		
1.3	Y	100				
1.5	E	41	49	5	4	
1.6	A	16	84			
1.7	A		94	1		5
1.8	Y	58		42		
1.9	Y	76		24		
1.10	E	83		17		
1.11	A	79	21			
1.12	Y		89	11		
1.13	Y		77	33		
1.14	E	8	73	19		
1.15	Y	37	52	11		
1.16	Y	14	54	32		
1.18	E	94		6		
1.19	Y	100				
1.23	A	97				
1.24	A	6	61	33		
1.25	A	98	2			
Raft River Valley						
2.4	Y	74		26	6	
2.5	Y	53	38	3		
2.6	Y	64	28	8		
2.8	Y	60	35	5		
2.9	Y	68	26	6		
2.10	Y	43	49	8		
2.12	A	100				
2.13	E	60		40		
2.14	A		100			
2.15	A	93	7			
2.17	A	10	90			
2.18	Y	63	33	3		

Table 19. Continued

Nest No. (1973)		Desert shrub	Crested wheatgrass treatment	Juniper	Alfalfa	Cereals
Curlew Valley						
1.3	E	50	32	19		
1.4	A	100				
1.5	Y	41	49	6	4	
1.6	Y	28	68	4		
1.7	A		94	1		5
1.8	Y	69		31		
1.9	E	82		18		
1.12	Y		89	11		
1.14	E	8	73	19		
1.16	Y	18	63	20		
1.18	Y	94		6		
1.19	A	100				
1.23	E	97		3		
1.24	Y	6	61	33		
1.25	A	98	2	33		
1.26	Y	27	31	3	38	
Raft River Valley						
2.4	A	74		26		
2.8	A	60	35	5		
2.10	A	43	49	8		
2.14	Y		100			
2.15	A		93	7		
2.17	E	10	90			
2.18	A	63	33	3		
2.21	A	14	86			
2.22	Y		90	10		
2.23	Y		95	5		
2.24	Y	5	88	6		
2.27	Y	5	86		9	
2.29	Y	96		4		
2.31	Y	21	73	2	4	
2.32	Y	99			1	

*Key: A=attended nests; E=nests with eggs; Y=nests with young.

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